The questions you aren't asking could be costing you money

Specifying a control system

By Rob Lanham, General Manager, Ross Systems & Controls

The business of creating an efficient mixing or blending system is a spectacular balancing act. The throughput you require must be balanced against batch size, agitator sizes, motor sizes, shear and tip speeds, viscosity, the thermal capacity of your product and heat-transfer media, energy costs, labor costs… and a hundred other variables. With so many equipment choices and tremendous competitive pressure to optimize performance, the mixing process itself has never been more complex. But in most cases today, the most challenging balancing act of all is still the specification of your process control equipment.

The process control system must balance your need for accuracy, consistency, flexibility and reliability against your need to control costs. This is why the control is now much more than the interface between the operator and the machine; it's a direct interface between your process system and your bottom line. Specify the process control equipment intelligently, and your production line will hum. Under-specify or over-specify the control system, and you're in for an avalanche of costs and delays.

Years ago, the control system and process control equipment were often little more than an afterthought assigned to a local contractor (who knew almost nothing about the process he was trying to control) and an overworked in-house engineer. Those days ended with the realization that the modern control is far more than a fancy digital version of an ON/OFF switch.

With the technology available today in sensors, integrated PID control logic, intelligent valves and central SCADA systems, every function in your processing system can be automated to operate at a terrific level of accuracy. But as accuracy increases, costs increase, too — and at an even faster rate. And this is where the most important balance of all becomes apparent: the balance between the accuracy that can be achieved and the accuracy needed.

How much accuracy do you really need?

In the typical process operation, raw materials are stored under specific conditions, then measured and transferred to a vessel in which they are transformed into an intermediate or final product. Often they pass through transitional vessels and process phases along the way.

Each turn along the process path is usually marked by well-defined tolerances associated with such parameters as product temperature, pH, viscosity, flow rate, and vacuum. Often these tolerances relate to both specific thresholds as well as the rate at which the set-point must be acquired.

For example, imagine a mixing process that consists of several distinct phases in a 100-gallon vessel. The transition from one phase to the next may require that we elevate the product temperature from 90 to 120 degrees C in 20 minutes. Our tolerance for both the target temperature level and the duration of the transition period is 2 percent (±1 percent).

That data — the performance specs and the required tolerance — invariably sets a dozen design wheels in motion.

• What type of heat transfer system is now available in the plant? Hot oil? Low-pressure or high-pressure steam? Hot water?

• Does the present heat transfer method rely on media with high process momentum? From a control perspective, this is a critical question. A method that operates with a high degree of momentum must be controlled much more carefully, and it usually requires a more sophisticated control strategy to avoid overshooting the target.

• What is the capacity of the present heat transfer system and the vessel jacket? Can we drive enough heat into the batch in that period of time?

• What is the volume of the vessel, the nature of the flow within the vessel, and the ability of the product to transfer heat from the vessel walls to the interior of the mass?

Stop!

Instead of charging into the engineering process, we should stop and first ask the question: In this case, is a 2 percent tolerance reasonable? What are the implications of performing this operation within, say, a 5 percent tolerance?

Often, the chief implications are that performance is unaffected and a lot of cost for unnecessarily sophisticated gear is eliminated. In the real world, "tolerances" are a moving target.

Process tolerances are generally born in the R&D process before the hand-off from R&D to process engineering. That is the point where the first of many well-intentioned adjustments are made.

Naturally, the project manager wants to make sure that the system works correctly when it hits the process line. So, when he sees a 5 percent (±2.5 percent) tolerance, he adds an extra margin of safety. He tells his equipment suppliers to work within a 3 percent tolerance.

The equipment supplier also wants to make absolutely sure that the final system performs as required. He, too, adds an extra measure of safety by tightening the spec. Now the 3 percent tolerance becomes 2 percent, and this degree of required accuracy triggers many expensive — and unnecessary — additions to the system design.

Often, this cascade of tolerance "adjustments" is even longer, and the end result is even more dramatic. Here is a rule of thumb that suggests where the key cost thresholds generally occur in the average mixing system.

• 5 percent tolerance: A 5 percent tolerance is easy to hit with the simplest control systems. An inexpensive dead band control with OPEN/CLOSE valves, for example, will usually suffice for batch heat control.

• 2 percent tolerance: When tolerances are pushed to 2 percent, the project requires significantly greater expertise in control engineering. Operation within a range of ±1 percent often necessitates using such

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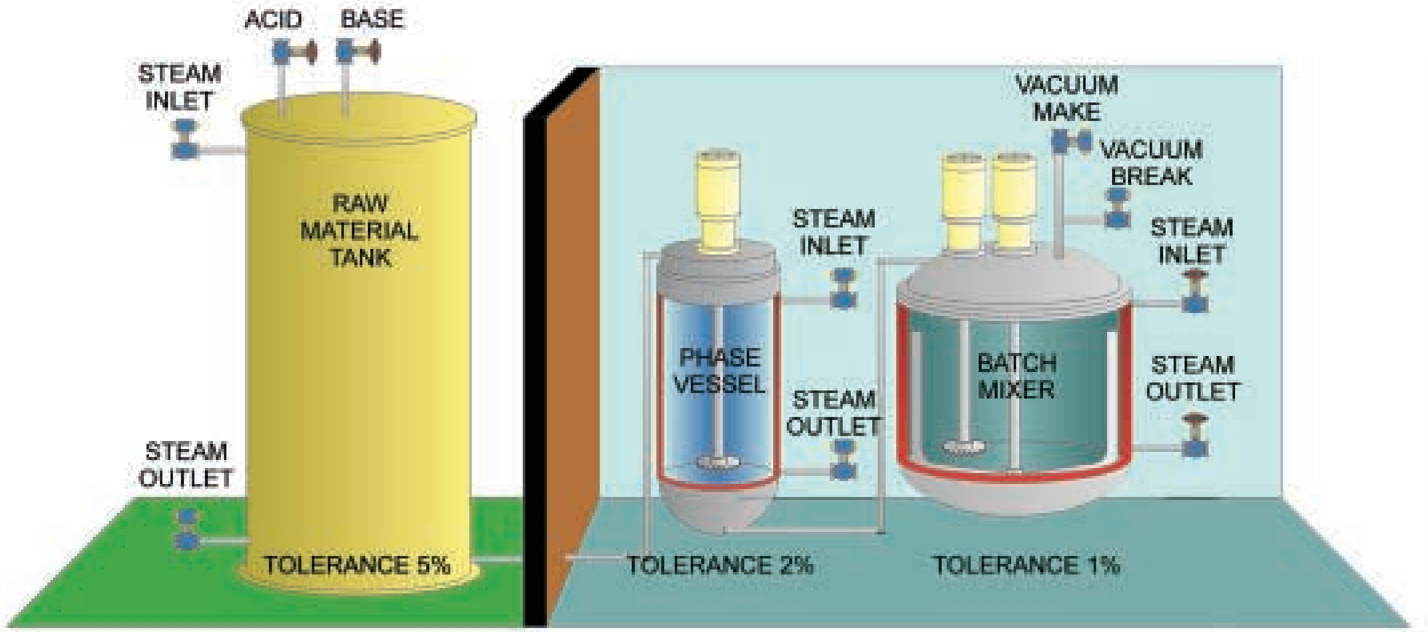

equipment as a proportional loop control or duty cycle control and a fast-acting OPEN/CLOSE valve arrangement. Equipment costs can increase substantially, depending on the specific equipment that you have standardized on.

To optimize performance and lower costs, match your controls to your "real" tolerances.

• 1 percent tolerance: In many applications, this requires a step up to PID loop control and fast-acting modulating control valves. (Forget about using a motorized valve that requires 22 seconds to open and close!)

This degree of accuracy requires far more costly equipment — and a lot of patience. You'll need to tune your controller carefully. Even with auto-tune, the process will still require multiple cycles as the PID controller gradually improves.

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The above illustration presents a hypothetical process system, including raw materials storage, a pre-mix phase, and a multi-step mixing phase. Each component requires equipment to sense and control key process parameters, including pH, product temperature, and vacuum. Control logic drives each process step.

The control solution suggested for each of the steps highlighted in this illustration reflects the most important principal of control design: Use proportional control solutions when the accuracy you need truly warrants the investment. Otherwise, use an alternative that is simpler and less costly. High-end control devices offer a great deal of flexibility, but often they are simply unnecessary.

Raw material tank: Tolerance 5 percent.

The material stored in this tank must be kept within a defined range of temperature and pH. Temperature = 80 - 95 degrees C, pH = 6.5 - 7.5.

This temperature requirement is easy to hit, especially since this system uses steam to apply heat. Unlike hot oil, for example, steam has very little momentum. In other words, when pressure is relieved, steam dissipates and heating stops almost immediately. We don't need to worry about overshooting the target temperature due to the residual heating capacity of the oil remaining in the jacket.

Temperature control solution: A simple dead band control with an OPEN/CLOSE valve arrangement will be sufficient.

Managing pH requires greater accuracy and more powerful control. As we drive pH up or down, we can easily overshoot our pH threshold. Further complicating the challenge, the effect of a constant volume of an acid or basic addition varies dramatically according to the pH of the batch.

A pH control solution: A fast-acting proportional valve with cascading PID control.

Phase vessel: Tolerance 2 percent.

The temperature in our hypothetical phase (pre-mix) vessel is somewhat more critical than in the raw material storage vessel. It must be maintained at 100 °C, and the product is susceptible to heat degradation at 140 °C. The vessel is equipped with a high-speed disperser that promotes product rollover and even heat distribution. Various raw materials are melted and blended here before they are transferred into the final mix vessel.

Temperature control solution: Proportional loop control/duty cycle control with an OPEN/CLOSE valve.

Batch mixing vessel: Tolerance 1 percent.

This vessel is equipped with a slow-speed anchor agitator to stimulate flow and a high-speed disperser to apply intense shear. The process takes place under vacuum, and heat is closely controlled with steam.

This process is variably temperature-sensitive. Each process stage requires a fast temperature ramp and a sustained temperature level that is extremely stable and accurate. Hot oil systems are generally the first choice when thermal stability is crucial. But to contend with fast transitions and close tolerances, steam remains the preferable medium for heat transfer in this part of the process system.

Temperature control solution: Tightly tuned PID loop control will be needed along with a fast-acting proportional valve.

In contrast, because vacuum and pressure develop virtually no momentum, they are easily controlled.

Vacuum control solution: A simple dead band control with an OPEN/CLOSE valve is adequate.

Intelligent process control: Based on common sense.

What does it take to build a process control system that optimizes performance and cost-efficiency?

1. Specs that are accurate and complete. Tolerances are probably the most vivid example of input that can distort the control design – and blow the budget – if they are allowed to drift. But the same can be said about innumerable process specifications. Even when they are "adjusted" to serve the best of intentions, "specification creep" can cause catastrophic problems.

2. A control designer who is intimately familiar with your process. A control designer who sees only the electrical dimensions of your project is working at a terrific disadvantage — and so are you! Involve him in the dynamics of the process itself, and he will be positioned to contribute meaningfully at every step along the way. Ideally, the control designer should communicate closely with the processing equipment manufacturer (not just the valve supplier) throughout the project (not just in the closing phase of the project). If their designs evolve in tandem, they're likely to produce much better results - on both your process line and your bottom line!

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3. A great sense of balance.

When should you apply sophisticated process control technology?

When should you choose a simple solution instead?

There is just no substitute for experience. Choose a process control expert who has done this before in applications like yours. This is your best insurance against winding up with a process control system that is over-designed, under-designed...or just plain poorly designed for your needs.

For more information, contact Charles Ross and Son Company at 800-234-ROSS or email sales@mixers.com.

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